# Outsourcing Decisions in Aircraft Maintenance

Prepared for the Federal Aviation Administration, under grant 99-G-007

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# List of Abbreviations

| | |
|---|---|
| ASI | Aviation Safety Inspector |
| ATA | Air Transport Association |
| ATOS | Air Transportation Oversight System |
| CASE | Coordinating Agency for Supplier Evaluations |
| FAA | Federal Aviation Administration |
| FAR | Federal Aviation Regulation |
| FBO | Fixed Base Operator |
| FSDO | Flight Standards District Office |
| GAO | General Accounting Office |
| MRO | Maintenance, repair and overhaul |
| NTSB | National Transportation Safety Board |
| OEM | Original Equipment Manufacturer |
| PMI | Principal Maintenance Inspector |
| RAA | Regional Airline Association |
| RFP | Request for Proposal |
| 3PMP | Third Party Maintenance Provider |

# Executive Summary

The Transportation Center at Northwestern University is currently under grant from the Federal Aviation Administration (FAA) to investigate the process of outsourcing maintenance in the airline industry. Airlines are continuing to rely on third party providers, both foreign and domestic, to perform various maintenance functions on all different levels. The objective of this study is to identify the most common criteria that the airline industry uses to select, monitor and assess the performance of their third party maintenance facilities.

In order to collect data for this study, an interview questionnaire targeted for maintenance personnel to answer was developed. The interview sought information about the entire outsourcing process and comprised four sections: background information about the airline, criteria the airline uses for selecting third party vendors, how the airlines monitor and assess vendor performance, and oversight by other entities. The responses to the questions formed the basis for developing performance measures for repair station operations.

A total of seven interviews have been performed to date, which include respondents from United States major, regional, and niche airlines. In addition, select questions were asked of a major, international carrier. The responses of the interview were input into a database in order to catalog and analyze them.

Most respondents stated that cost is the driving force behind outsourcing, but the performance of a repair station determines how much cost savings is realized. The ability for the repair station to deliver the work to the quality level and time frame promised is very important. Most of the information that airlines track from their repair stations are billings and discrepancy reports. Any anomalies in this documentation will trigger a closer investigation of the work performed by the repair station. In addition, most respondents reported that they had on-site personnel at repair stations while contracting major maintenance. Respondents stated they only report major problems with repair stations to the FAA.

Using the analysis as a basis, performance measures were developed as variables within certain areas of repair station operations that the respondents stated they monitored. The area of repair station capabilities refers to the capability of a repair station to offer certain services. Under repair station capabilities, performance measures track the labor, certification and ratings of the repair station and tools and test equipment possessed. The area of repair station performance refers to the quality of work that is actually performed. Under repair station performance, the performance measures indicate areas of repair station performance that might be indicative of poor quality work. The area of repair station administration refers to the overall organization and operation of the facility. Under repair station administration, performance measures track the financial matters, growth, and management changes with the repair station.

As the airlines are ultimately responsible for the work performed by their contracted repair stations, they usually provide some degree of support to the repair station. For this reason, performance measures for airlines that contract major maintenance to repair stations were

also developed. These performance measures focus on the level of support the airline provides the repair station. Finally, performance measures that the respondents identified as being of marginal importance are also presented.

The next phase of this research will focus on refining the existing performance measures and defining new ones. The results of the interviews have also identified additional issues which will require more in-depth investigation. Additional information will be gathered from new respondents as well as those that have already been interviewed.

# 1. Introduction

## 1.1 Background

Third-party aircraft maintenance providers (3PMPs) are relied upon by airlines and lessors to perform various maintenance tasks. Outsourcing is an attractive option for operators that do not have a sufficient number of aircraft in a particular fleet type to justify the expense of trained personnel, facilities, tooling and test equipment required to perform the maintenance function internally. In this situation, substantial savings are realized when maintenance is performed externally. A 3PMP will usually have multiple contracts and the larger density of work allows the 3PMP to complete such tasks at a lower cost to the operator.

Due to increased demand for third party maintenance services, the number of 3PMP continues to grow. In a 1997 General Accounting Office report, it is estimated that one-half of the maintenance performed by United States airlines is actually outsourced to a 3PMP. This has created an extremely competitive environment within the industry. While cost savings may be the initial motivation to outsource, there are many other factors to be evaluated. For example, the quality of the work performed is a significant consideration in the selection of a 3PMP. Poor quality of maintenance and repair will result in decreased reliability of the aircraft, which in turn quickly erodes any cost savings gained by contracting with a 3PMP.

The practice of outsourcing has resulted in significant changes regarding how quality control and compliance are monitored. When a task is outsourced, the operator of the aircraft is still responsible for compliance of the 3PMP with respect to the operator's approved policies, procedures and requirements. To ensure compliance, the operator is compelled to revise procedures to account for 3PMP involvement. This implies that the operator will most likely spend additional time and resources auditing the 3PMP and inspecting aircraft for compliance. Moreover, FAA oversight of the operator will require revision to include the third party maintenance facility that completes work for the operator.

Oversight of the outsourcing process has become an increasing concern in light of the ValuJet accident of May 1996. In response to this incident, the FAA has created several initiatives to improve the oversight of 3PMPs. One specific initiative is to improve the information and data collected from both operators and 3PMPs in relation to outsourcing.

## 1.2 Objectives

To gain a better understanding of the process of outsourcing maintenance and its implications for the FAA and the air transport community, the Transportation Center at Northwestern University examined the criteria for the selection and qualification of third-party maintenance facilities by the major airlines. This objective was accomplished by interviewing the appropriate maintenance executives at major, niche, and regional airlines. Based on these findings, prototype performance measures are identified that may be used to determine whether further work will be assigned to such a maintenance service provider.

The purpose of this proposed study is two-fold. The interviews uncovered the data and information that is currently collected by operators of aircraft and identified areas in which the data is insufficient. Second, the performance measures that are developed provide a basis in which to rate certain characteristics of 3PMPs. Collectively, these two outcomes will provide additional insight into the outsourcing process.

## 1.3 Research Methodology

An interview process provided the primary means of gathering information and data for this study. Four broad areas were investigated:

- Background information

This section seeks to gain background information about the airline with which the respondent is associated.

- Criteria for third party vendors

This section focuses on how airlines identify potential vendors, the requirements of both the airline and the vendor for each other, and how contracts are awarded.

- Monitoring and assessing vendor performance.

This section focuses on what an airline monitors in terms of vendor performance and how that is completed.

- Oversight by other entities.

The questions in this section see information regarding the airline's relationship with Coordinating Agency for Supplier Evaluations (CASE), industry groups, and the FAA.

## 1.4 Overview of report

This report details the activities that were conducted as part of the Outsourcing Decisions in Aircraft Maintenance project (grant 99-G-007). The *Literature Review* chapter describes outsourcing practices and trends in the aircraft maintenance industry. The *Research Methodology* chapter details the development of the interview document and corresponding protocols in administering the interview. The *Analysis of the Interview Results* chapter reports the data that has been collected as part of the interview process and the analysis of the data. This analysis forms the basis of performance measures for repair stations which is explained in the *Development of Performance Measures* chapter. The final chapter, *Summary and Conclusions*, lists the major findings of this project.

# 2. Literature Review

## 2.1 Introduction

This chapter summarizes the current literature in the area of third-party civil aviation maintenance. Source documents that were consulted in its preparation were drawn primarily from industry periodicals appearing from 1990 to the present.

## 2.2 Size and Scope of the Aircraft Maintenance Outsourcing Industry

For the purpose of this review, maintenance is defined as any one of the set activities that must be performed so that an aircraft remains in a condition of airworthiness. Activities falling under the maintenance umbrella include all those commonly referred to by the term Maintenance, Repair, and Overhaul (MRO). These activities occur on a continuum from the Daily Check to the "D" Check as described for older model Boeing 737 aircraft in the article by O'Mahoney. (O'Mahony 1992) Outsourcing occurs when anyone other than the airline's direct employees perform any of these activities. A 3PMP carries out work done in this fashion.

Estimates vary as to the size of the market for MRO services. In their 1993 article, Cala and Bond estimated the MRO market at between $18 and $24 billion annually and the MRO share thereof at 27 percent in 1989 and 23 percent in 1990. (Cala and Bond 1993) In their 1997 article, McKenna and Scott cite an annual market size figure of $23 billion and a 3PMP share of 30 percent. (McKenna and Scott 1997) In her 1999 article, Gallacher states that the MRO market is "worth more than $25 billion a year." (Gallacher 1999)

The total set of 3PMPs can be divided into two categories. The first includes portions or the totality of the major carriers' maintenance divisions that have now been established as stand-alone companies (e.g., UAL Services) providing MRO services for the parent carrier and other carriers. This step was taken, in part, to expose maintenance divisions to the downward cost pressures in the MRO market and to achieve subsequent savings for the parent carrier. (Feldman 1992) The second set includes those providers focusing on a single component, such as engines, or those that have growth through merger or otherwise in order to better capture share in the growing MRO market.

In addition, an annual directory appears in the publication Flight International. (Warwick 1998)

Although there has been considerable change in the MRO market over the past decade, predictions for excess capacity have remained constant. While increasing fleets of aging aircraft and the associated increased need for 3PMP services caused significant entry in the late 1980s and early 1990s, the demand never materialized as the economic downturn of the early 1990s eliminated carriers from the field.

Today, it is expected that 3PMPs will deliver an increasing percentage of MRO services as new aircraft types enter carriers' fleets and they decide not to invest in the new maintenance capability. (Gallacher 1999) There remains concern as to whether even this augmented level of services to be performed is sufficient to maintain the current 3PMP population. It is feared that the population will again increase as it did in the late 1980s, only worsening the prospects for 3PMP profitability in the near to medium term.

## 2.3 Motivation to Outsource

In the documents reviewed, cost reduction is the most noted reason for outsourcing. According to a Booz-Allen & Hamilton study, "maintenance and engineering is increasingly a key lever to achieve cost differentiation." (Booz-Allen & Hamilton 1994) The same study found that the use of industry-best practices can reduce cost by 20 to 30 percent. The need to control costs is necessitated by different factors depending upon the type of carrier.

As with many recent developments in civil air transportation, outsourcing is a product of deregulation. Increasing price competition has caused carriers to examine all possible ways to control costs. In turn, maintenance is an area that has received particular focus from carriers for two reasons. First, it represents from 15 to 20 percent of a carrier's direct operating costs. (DeLauro 1994) This is the largest area of expenditure that can be influenced in the short term and that can be so done through carrier choices. While aircraft fuel and salaries represent larger line items, the former is largely dependent upon market forces and the latter, generally, is governed by long-term contracts.

Aging aircraft fleets require more frequent visits to and longer stays in the maintenance hangar to maintain airworthiness. Both of these represent significant costs to carriers in terms of lost passenger revenue and increasing maintenance expenditure with age, respectively. As the sum of these costs represents a larger portion of a carrier's bottom line, it is likely to receive increased attention. In turn, carriers are more likely to turn to 3PMPs who, through economies of scale and gains achieved through specialization in fleet types and maintenance procedures, are more able to reduce cost than if the work were performed in-house.

For start-up carriers with a small fleet, the cost of acquiring the infrastructure and personnel necessary to maintain a single aircraft type is prohibitive. The incremental cost of obtaining the necessary inputs to maintain the first fleet type added is significantly more than adding the second and subsequent fleet types owing to economies of scale and scope created in the latter situation. Many low-fare carriers have only one type of aircraft. Furthermore, smaller fleet sizes than the majors provide less opportunity to spread out fixed costs.

Given their specialization in both procedures and aircraft types, 3PMPs are able to attain cost savings in the three areas that are the primary cost drivers in the maintenance area: scale, labor rates, and productivity. (Condom 1994)

According to a 1994 report, MRO labor rates vary from a low of $10 per man-hour in Southeast Asia to $40 in Japan and Germany. (Booz-Allen & Hamilton 1994) Of the three

cost drivers, this is the most significant. Maintenance, particularly 'heavy' checks, requires a great deal of man-hours. Hence, 3PMPs offer an important source of cost savings if prevailing labor rates at the provider's facility are lower than those of potential customers.

The importance of this cost differential is at the heart of the recent 3PMP expansion into China and other countries in Southeast Asia. AMECO-Beijing (Aircraft Maintenance & Engineering Corporation), a 60/40 venture between Air China and Lufthansa Technik, is but one example of this growing trend. (Hill 1996)

There are significant opportunities for cost reduction in aviation maintenance that present themselves as the amount of work performed by a single entity increases. Furthermore, this opportunity increases as the intensity of the work to be performed increases. This is most notable for heavy checks. This stems form the ability to spread the cost of the complex infrastructure, training, and parts necessary to perform such checks over an increased number of aircraft. 3PMPs also offer carriers important economies of scale in the areas of engine maintenance and spare parts administration.

As concerns engines, Williams cites GAMCO sources in his article who state that a single lathe can cost as much as $6 million. Furthermore, he explains that the increased reliability of engines has caused the time between overhauls to increase. As such, few carriers have the engine inventory necessary to achieve a minimally efficient engine overhaul operation. (Williams 1994a)

According to Phillips, in 1996 airlines spent $7 billion per year to maintain a spare parts inventory worth $35 billion. Hence, considerable savings can be achieved when inventories are consolidated and administered by 3PMPs or other third parties. The potential savings are particularly important for rotables – high-cost parts that can be repaired and maintained for the life of the aircraft. Phillips reports that KLM aims to eliminate its inventory of spare parts, outsourcing this function to others. Other carriers are somewhat more cautious, wanting to ensure that parts availability savings do not come at the expense of schedule reliability. (Phillips 1996)

Through specialization, 3PMPs are able to apply learning about the maintenance of a certain aircraft type sooner than an individual carrier would. This is known as the learning curve effect or the experience curve. In order to maximize the benefits derived from this 3PMP advantage, carriers must identify those maintenance needs that are the strategic and then structure long-term partnerships with those 3PMPs that are able to provide the advantage. (DeLauro 1994) In so doing, both parties share the benefits from achieving supply chain efficiencies.

Although the advantages from the learning curve effect increase at a decreasing marginal rate, 3PMPs are able to stay ahead of carriers. Consequently, 3PMPs are usually able to perform the same repair in a shorter period. This is significant given that, particularly for large aircraft, lost revenue from time out of service is more important that the significant costs incurred in the hangar. 3PMPs, particularly those that do not enjoy a labor cost

advantage such as SR Technics, often accentuate this fact when bidding for maintenance contracts. (Vandyk 1996)

## 2.4 Outsourcing Issues

There has been a clear shift in both the U.S. and foreign markets from a system in which carriers maintained their own fleet of aircraft to one in which carriers and a variety of 3PMPs perform this task. Regulatory reforms have been necessary to update a system in which regulatory inspectors focused upon carriers' efforts to maintain their fleets. This has both increased the focus on carrier responsibility and on regulatory oversight.

In the period following the ValuJet mishap in the Everglades, much was written about the carrier's apparent lack of necessary oversight of its 3PMP providers. Furthermore, many began to wonder whether low-fare startup carriers such as ValuJet had the wherewithal to supervise adequately outsourced maintenance activity. Given the side array of 3PMPs employed by a single carrier, Sparaco notes an increasing difficulty for carriers – even large ones – to keep up with the increasing complexity. (Sparaco 1996)

While the FARs have always dictated that carriers were responsible for the overall airworthiness of their fleets, this provision was made more explicit after ValuJet. Furthermore, changes to the methods of aircraft maintenance oversight were made following the ValuJet incident. These included requiring carriers to demonstrate that each of its 3PMPs were able to maintain aircraft in a condition of airworthiness and the revision of standards for those inspectors assigned to monitor 3PMPs. (Phillips and Mann 1996)

Despite the changes mentioned above, there has been continuing criticism of FAA oversight. The U.S. General Accounting Office (GAO) has highlighted three areas in need of improvement. In a 1995 report to Congress, GAO found need for improvement in FAA/Flight Standards analytical capabilities. While the agency's efforts to use the data to identify potential safety problems were deemed adequate, GAO found that the data upon which the analysis to be inadequate and in need of improvement. (United States. General Accounting Office 1995)

A 1997 report to Congress dealt specifically with FAA oversight of repair stations. GAO found that visits to 3PMP facilities by a team of investigators were more likely than those by individual inspectors to identify deficiencies. Despite this, the FAA employed a single investigator method. In addition, the GAO was unable to determine efficacy of follow-up action based on the FAA's records. (United States. General Accounting Office 1997)
This year, GAO issued its opinion on the Air Transportation Oversight System (ATOS). Whereas past issues concerning the use of data in the pursuit of airworthiness assurance had been addressed, the complexity of the ATOS system required significant training for each of the FAA's inspectors. More time for this training would be necessary than that allotted by the FAA. (United States. General Accounting Office 1999)

The shortage of qualified maintenance personnel has been referred to frequently throughout the documents reviewed for this report. In 1991, Reed cited the increase in the maintenance required for an aging fleet of aircraft. (Reed 1991) In a 1998 article, he discussed the acute shortage of qualified personnel given a tight labor market and relative undesirability of the hangar environment for individuals who require an increasing amount of computer skills. (Reed 1998) There is no alleviation of the shortage predicted in the near to medium term.

Nearly all of the documents reviewed assumed a carrier's 3PMP choice as given. A GAO report from 1990 identifies economic conditions, availability of resources, changes in regulatory requirements, and changes in costs and prices as the factors that carriers must consider when choosing a 3PMP. (United States. General Accounting Office 1990) Two articles by Williams discuss carrier criteria and explore the benefits to be gained from outsourcing. (Williams 1994a; Williams 1994b)

None of the documents reviewed specifically deals with the steps a carrier must take in order to choose between 3PMPs. There is a need for such work as increasing numbers of carriers make an increasing number of outsourcing decisions

# 3. Research Methodology

## 3.1 Introduction

The primary focus of this research is to investigate how airlines manage the process of outsourcing their maintenance function. In order to ensure consistent collection of data, a formal interview process was developed. This consisted of developing a standard list of questions to be used during an interview, as well as a protocol for dealing with participants in the study.

## 3.2 Interview Development

The information being sought in this study is gathered primarily from the perspective of aircraft maintenance personnel. The target interview respondent was an airline representative working in the maintenance area, primarily in a quality control capacity. Consequently, the questions were targeted to this type of respondent.

The interview questions were developed to map the process of how an airline outsources any maintenance function. The interview document is comprised of four sections:

- Background information

This section seeks to gain background information about the airline for which the respondent works. The questions focus on the size of the airline and the practices of the maintenance department, e.g., how much maintenance is outsourced, typical maintenance functions outsourced, and which types of vendors the airline contracts.

- Criteria for third party vendors.

This section focuses on how airlines identify potential vendors, e.g., the requirements of both the airline and the vendor for each other, and how contracts are awarded.

- Monitoring and assessing vendor performance.

This section focuses on what an airline monitors in terms of vendor performance and how that is done. In addition, this section seeks information as to the process of contract renewal or termination.

- Oversight by other entities.

The questions in this section seek information regarding the airlines' relationship with Coordinating Agency for Supplier Evaluations (CASE), industry groups, and the FAA.

A complete listing of questions in each section is provided in Appendix B. The interview was designed to be completed in about an hour so as to minimize disruption to the schedule of the respondents.

## 3.3 Protocol

A protocol in dealing with the survey respondents was developed. The protocol ensures that the information that is collected from each respondent is consistent.

As most airlines vary in terms of organization, it was to be expected that the actual job title of the respondent would vary as well. However, the interview was designed to be answered by a representative from the maintenance division. Ideally, the respondent would be the overall manager of outsourced maintenance. If there was a team of people that worked in this capacity, the representative from the quality control division of the maintenance department was contacted.

The airlines that participated in this study were identified primarily by contacts from previous research. Additional airlines were identified by FAA aviation safety inspectors, and in most cases a contact at the newly identified airline was furnished by the panel member. All potential respondents were contacted initially by telephone, and were provided with a brief summary of the study objectives and requirements. During this initial discussion, the involvement of the respondent was requested, arrangements were made to meet, and a follow-up letter was sent to confirm.

All interviews were conducted in person to ensure consistent application and interpretation of the questions. Each question that was applicable to the airline of each respondent was asked. After completion of each interview, a follow-up letter was sent, thanking the respondent for their time.

In order to ensure a non-threatening environment for the respondent, specific responses to the interview questions were considered confidential. Neither the airline, nor the individual participating in the interview will be named in this report.

## 3.4 Analysis

In order to store the information collected from each respondent, a database in Excel format was developed. This method allowed easy comparison of responses to each question from each airline in the sample. In addition, graphical depictions of the responses could be easily generated and appropriate statistical analysis of the data could be performed. While some quantitative data was collected from each respondent, the bulk of the information sought was qualitative.

## 3.5 Performance Measures

The analysis will be used to generate performance measures in order to rate certain characteristics of repair stations. The focus will be on determining when the repair station is operating in a manner that might result in an unfavorable condition. This will be accomplished by grouping similar or insightful responses which indicate certain portions of

the repair station should be monitored. Specifically, these performance measures should have implications for the FAA.

# 4. Analysis of Interview Results

## 4.1 Introduction

The primary objective of this study is to determine what criteria airlines use to select 3PM providers. Based upon this information, performance measures to monitor the quality of vendor work are to be developed. The analysis of the interview data is presented in such a manner to facilitate the process of developing these performance measures.

## 4.2 Facilities Interviewed

To date, a total of seven interviews have been completed. This includes two major airlines, three regional airlines, and two niche airlines. In addition, select questions were asked during a visit by another researcher to a major, European based airline.

The job titles of the respondents that were interviewed varied. At the major airline, in one case there was a manager of contracted maintenance, while in another case the respondent was a manager in the quality control division. At the regional airlines, one respondent was the director of quality control, while the other was the manager of warranties in maintenance. At the niche airlines, both respondents were the directors of maintenance.

## 4.3 Background Information

All of the airlines that participated in this study outsourced at least part of their maintenance function. While most respondents indicated that costs were a major reason for outsourcing their maintenance function, they also cited several additional, interrelated cost drivers that were taken into account. Figure 4.1 depicts the considerations that the sample of respondents made when deciding to outsource maintenance tasks.

Reliability and adherence to work schedule are two such factors. One respondent stated that the potential revenue loss for an aircraft that exhibits poor reliability is always greater than any cost savings achieved from outsourcing the maintenance in the first place.

The other cost driving factors are labor considerations and the need for specialized equipment. The labor consideration deals with training and expertise of the workforce to complete certain tasks. Many respondents commented that a repair station often had the expertise in their facility to complete specialized tasks. Furthermore, repair stations also possessed any specialized tooling required to complete tasks that may be cost prohibitive for the scale of work that the airline might require. The capabilities of the repair station also come in to play in with these considerations. A repair station may be able to complete the work more quickly due to its expertise in a certain area. This translates to a cost savings to the airline in terms of decreased down time of an aircraft.

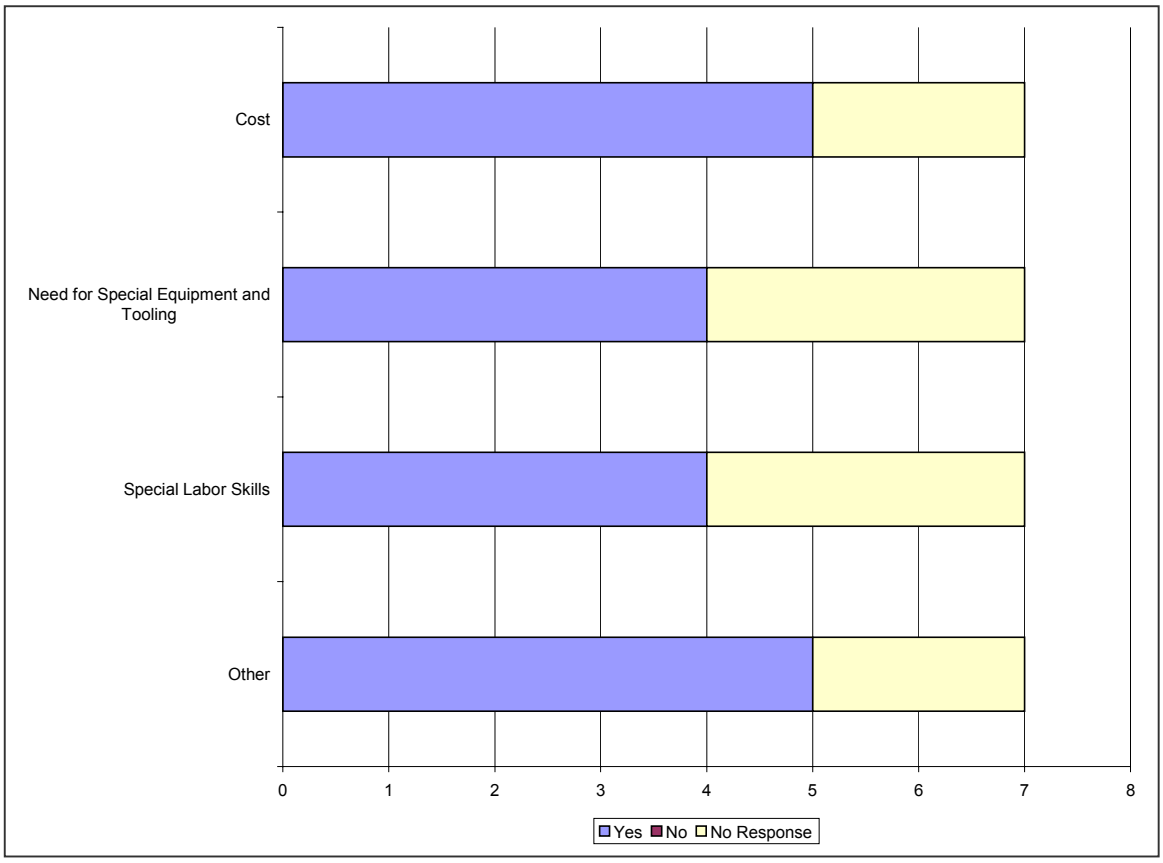


**Figure 4.1. Factors Considered When Making Outsourcing Decisions**

The scale of outsourcing within the sample of airlines interviewed also varies. Figure 4.2 shows how many of the airlines outsourced some common maintenance functions. Line maintenance functions were typically outsourced at the stations away from their bases or overseas. The niche airlines were the only respondents in the sample to outsource their light (A&B) schedules checks. Niche airlines also outsourced their heavy scheduled checks (C&D). However, other airlines also reported that they outsourced their heavy checks as well.

Almost all of the respondents stated that they outsourced at least some of their component overhaul to repair stations. The primary reason for this was the lack of expertise and tooling in-house. Engine maintenance was most likely to be outsourced for the same reasons. Likewise, all respondents stated that other maintenance was performed by a third party. This included such items as propeller overhaul, painting of aircraft, composites, and specialized avionics works.

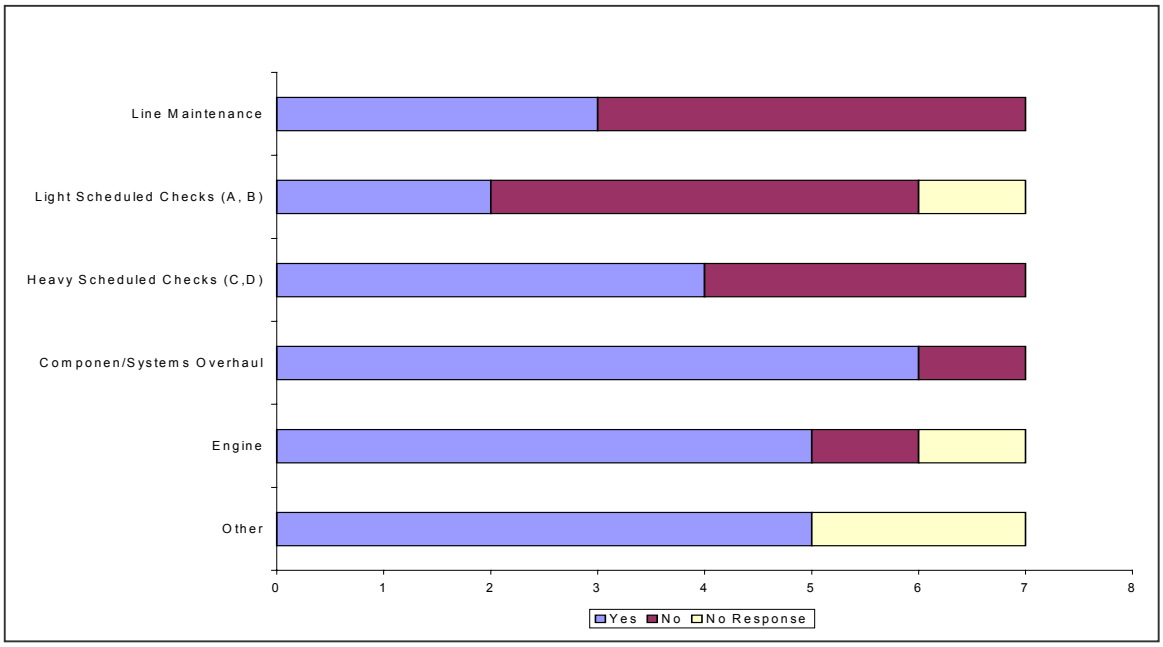


**Figure 4.2. Typical Maintenance Functions Outsourced**

Figure 4.3 depicts the types of outsourcing providers that the respondents currently used. All except one of the respondents stated that they employed repair stations. One respondent was careful to note that the term repair station referred to facilities that hold a FAR Part 145 repair station certificate. All except one respondent had contracts with component shops. Only two respondents used fixed base operators (FBOs), and only in the case of on-call maintenance at out stations. Four of the seven respondents mentioned that they contracted with other airlines to perform some of their maintenance related tasks. In most of these cases, these airlines had spun-off repair stations that were still a part of the airline. The other entities that the respondents contracted with were the original equipment manufacturers (OEMs).

Of the seven respondents, only one airline had a company-imposed limit regarding the percentage of their maintenance responsibilities that could be outsourced (Figure 4.4). This limit is set at 20% of the total maintenance function, which is a constraint that is imposed by the union contract. This particular respondent also noted that their airline only outsourced 10% of the maintenance function at the current time. Other respondents that were unionized mentioned that the union is sensitive to issues related to outsourcing, but that there was no formal limit stipulated in their contract.

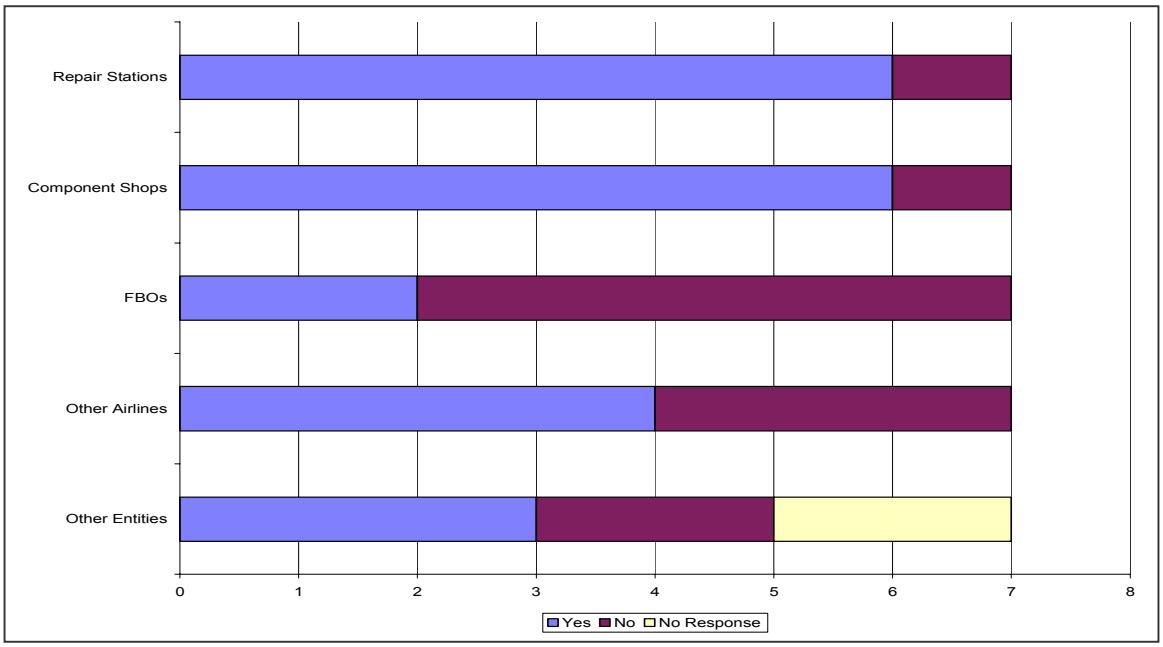


**Figure 4.3. Types of Outsourcing Providers**

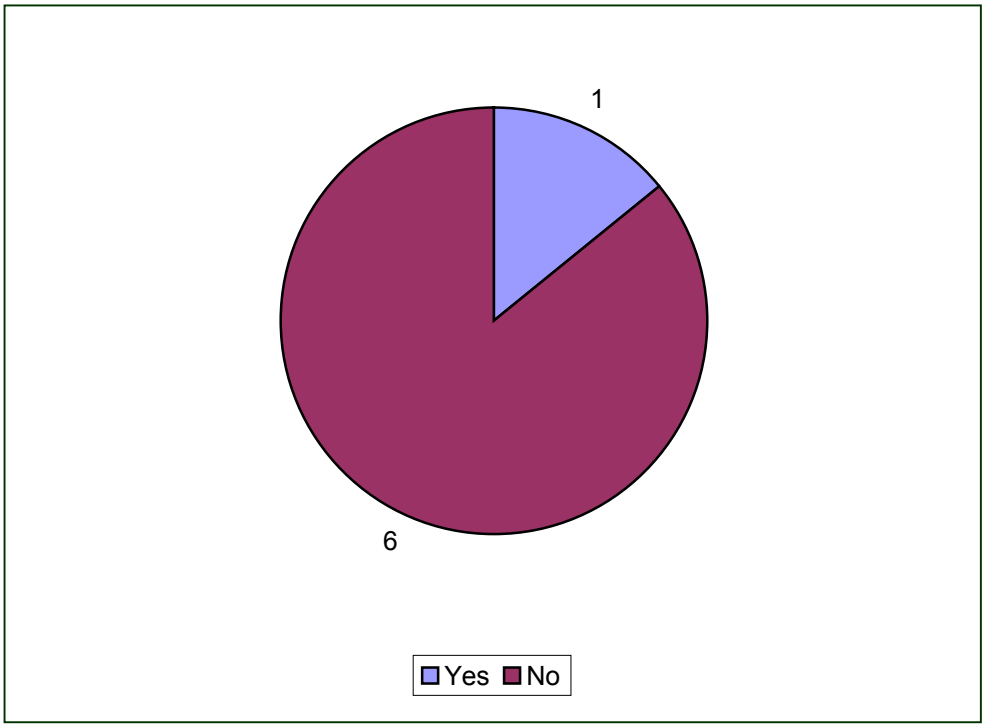


**Figure 4.4. Limitations on Outsourcing**

## 4.4 Criteria for Third Party Vendors

In identifying potential maintenance providers, the respondents relied heavily on reputation and recommendations from other users of maintenance (Figure 4.5). One respondent has a fleet of one type of aircraft. In organizing their maintenance department during the start-up period, they simply identified the vendors that had known capabilities for their particular fleet of aircraft. Other respondents relied on information obtained at trade shows or operators' conferences.

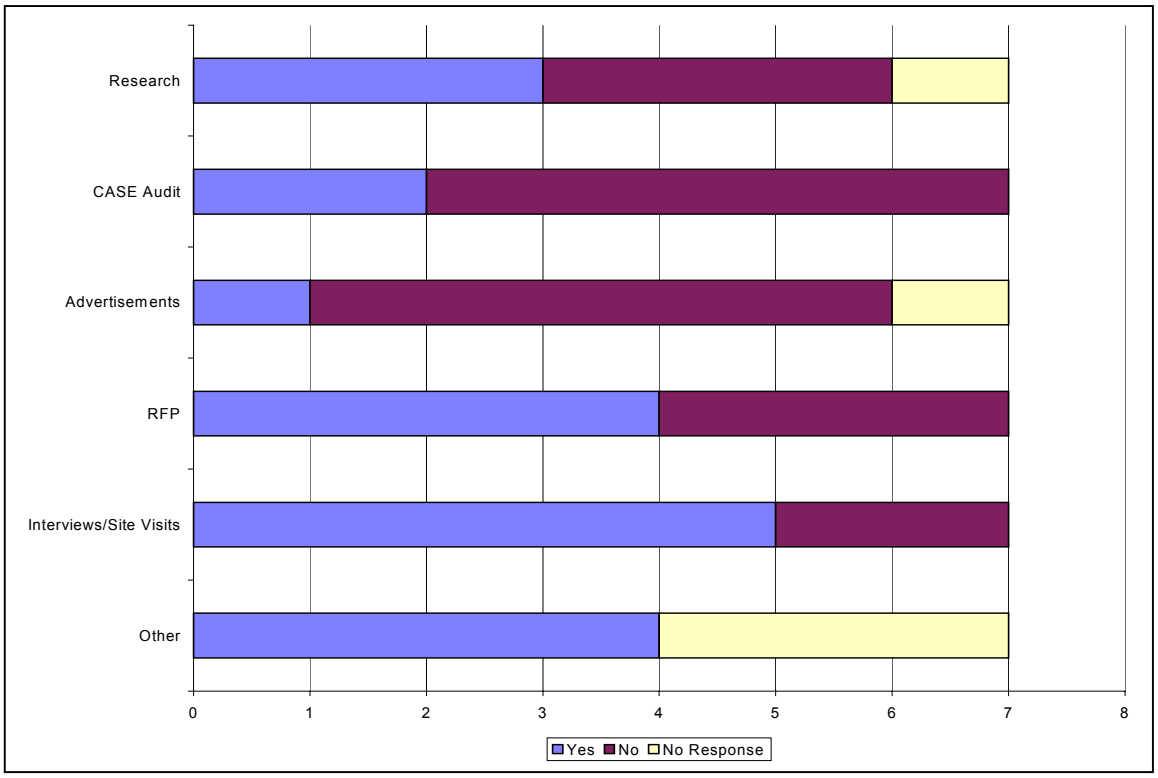


**Figure 4.5. Methods Used to Identify Potential Maintenance Providers**

Most respondents that were outsourcing larger projects issued request for proposals (RFPs) also conducted on-site interviews with the vendors being considered. The respondents that did not issue RFPs or conducted interviews typically were outsourcing smaller projects, primarily component overhaul.

Four of the respondents are members of Coordinated Agencies for Supplier Evaluations (CASE). Only two of the respondents stated that they used CASE audits as a source of identifying information when identifying potential providers.

Three of the seven respondents commented that they consulted the principal maintenance inspector (PMI) of the repair station of a potential provider (Figure 4.6). One respondent then qualified this response by stating that this is done indirectly as part of their audit of the repair station. Another respondent said that they would only consult the PMI if they discovered an enforcement action that was considered significant.

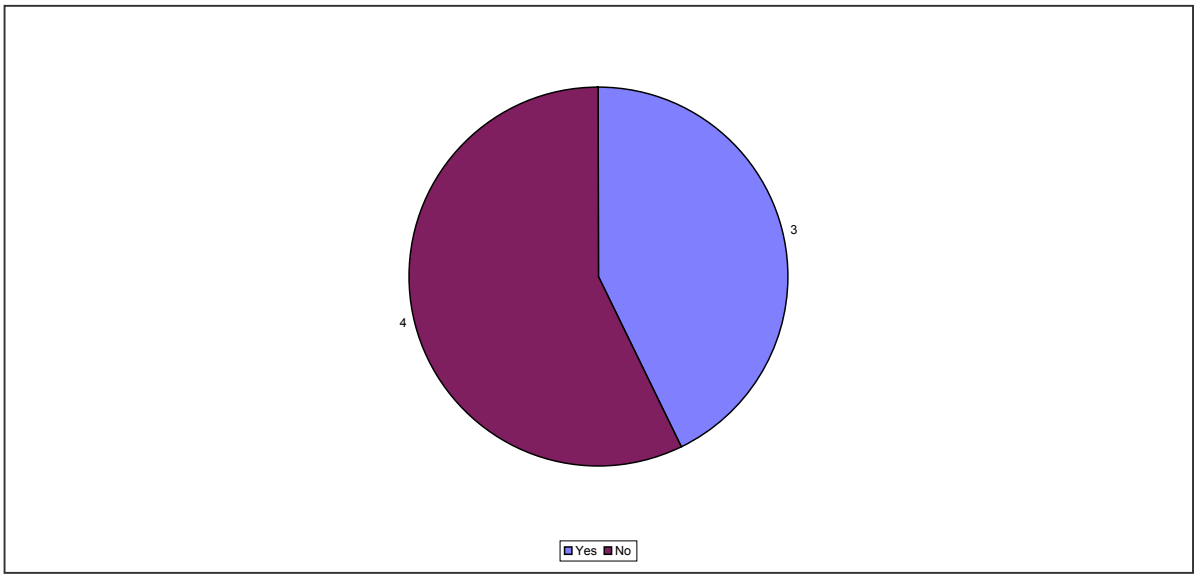


**Figure 4.6. Respondents That Consult the PMI of a Potential Provider**

In the process of identifying potential maintenance providers, the respondents stated that foreign repair stations were considered differently than domestic repair stations only for other than safety related reasons. The primary reason for considering foreign differently than domestic is geography and the related time and costs in dealing with a vendor that is located far away. One respondent mentioned that foreign repair stations would have to complete work more quickly in order to be competitive with domestic repair stations due to the increased travel time to reach the repair station. When asked if repair stations required any special oversight by the firm, all respondents answered no.

Figure 4.7 depicts some of the criteria that the respondents considered regarding the provider's workforce. Most respondents did not consider the make-up of the labor force of the potential provider. Only one respondent critically looked at these issues. This respondent commented that all leads and inspectors must have an A&P and that they also evaluate the number of contract versus permanent employees. The contract employees were considered an issue since it was felt that as the number of contract employees increases, so does the likelihood of inconsistent training and potential problems. Average experience of employees was also a factor that was considered. Wages were not considered by any respondent, with one response qualified with the statement that most repair station wages are in a similar range.

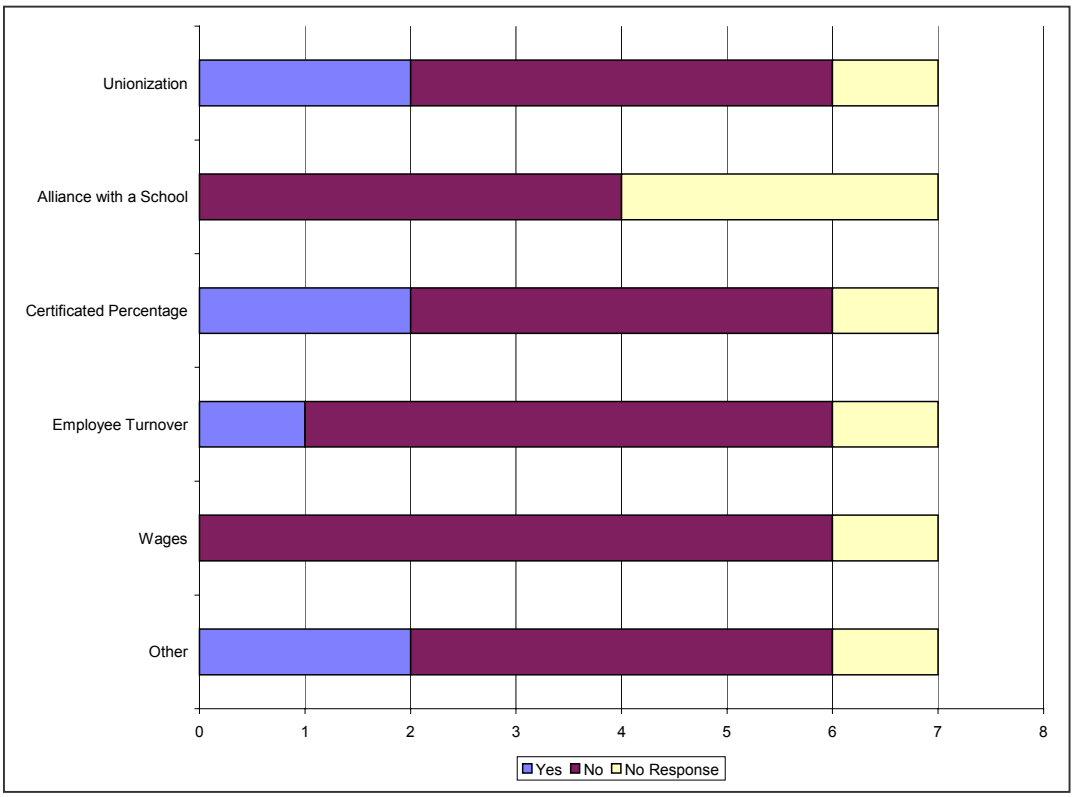


**Figure 4.7. Workforce Considerations for Repair Stations**

Financial status of provider was a consideration for most of the respondents. However, only one of the respondents stated that a credit check was actually performed, while two respondents stated that they did consult publicly available financial information about the potential provider.

When queried about any specific requirements that the respondents may have for their potential 3PM, most respondents provided examples that are standard. For example, the appropriate documentation including maintenance manuals, must be provided. Only one respondent replied that they required any special insurance beyond what they considered the industry norm. This respondent also stated that the vendor would also require special insurance coverage as well.

In making the final decision to accept a proposal from a potential contractor, the respondents stated that performance and cost were the two most important criteria in comparing bids from potential providers. All respondents stated that it was an equal balance between these two criteria. Guarantees were not stated as important in the initial decision to award a contract to a vendor. However, on-time performance is explicitly written into the contract to ensure satisfactory performance on the part of the vendor. Contract periods also vary according to the specific bill of work, which varies by the number of aircraft and the complexity of the task. Specific answers varied from 18 months to 3 years, with three respondents stating three

years. Most respondents stated that contracts are often modified to reflect changes in scale and scope and that the change is usually mutual.

## 4.5 Monitoring and Assessing Vendor Performance

Most respondents said that company personnel are on-site at a vendor for some period of time (Figure 4.8). When company personnel are on-site with a vendor they function as a liaison between the airline and the vendor and as a resource to the vendor. With larger contracts, the respondents stated that company personnel are on-site full-time. The number varies from one to seven people, depending on the scope and scale of the particular contract. All but one respondent said that on-site personnel were company personnel. In the case where the on-site personnel were contracted, the contractor has actually been a previous employee of the vendor.

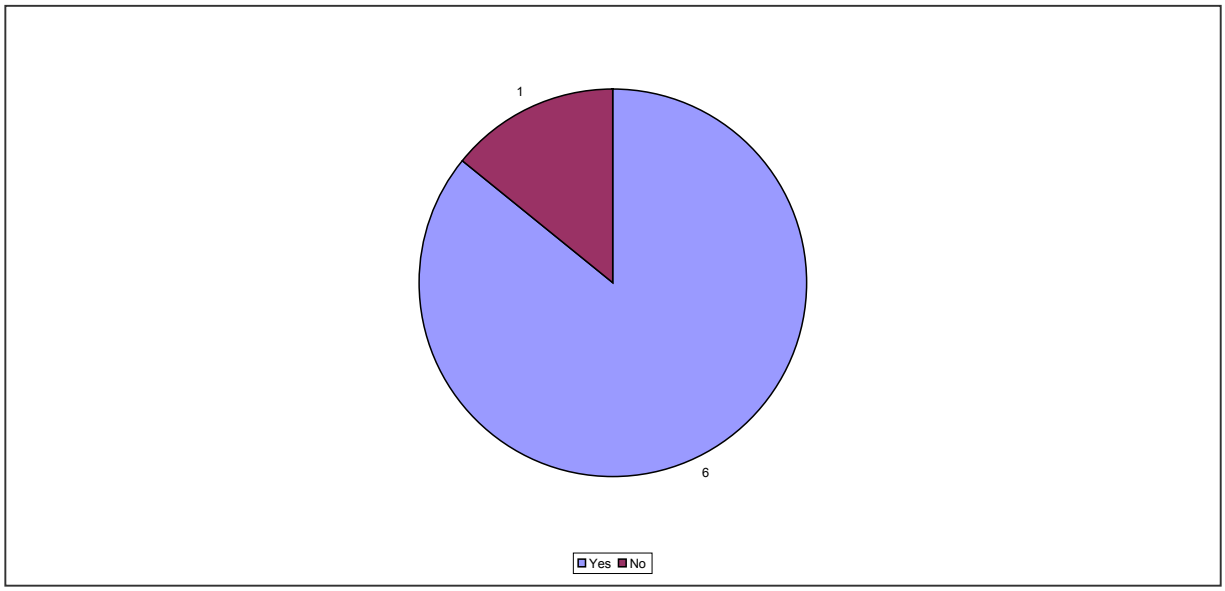


**Figure 4.8. Company Personnel On-site at a Vendor**

The on-site personnel function as advisors to the jobs and keep track of progress and problems. They are usually maintenance personnel with a variety of experience. They also audit the work that is being performed by the vendor.

The respondents reported a variety of data that is collected by the airline about work being performed by a vendor. The sources of this information include billings and invoices, required FAA documentation, discrepancy reports, and installations and removals reports.

All respondents stated that quality assurance measures that apply for all work done by the airline apply to the work performed by any vendor. Most respondents said they did not

perform any special audits on the work performed by vendors. Three respondents said if they did audit any work, it was done because someone discovered something out of the ordinary and suspected further problems.

Five of the seven respondents said that they had procedures that were completed after the aircraft had been returned from a vendor. This most frequently involved what one respondent defined as a conformity/acceptance check. This type of check involves reviewing the documentation to ensure that all paperwork is in order and that all procedures have been properly followed. One respondent stated that they performed a special seven day monitoring of the aircraft after it had been returned from the vendor. Another respondent stated that any work that has been outsourced is reflected in their internal paperwork and tracked to see if there are any differences between what services had been provided and what work had actually been completed.

Five respondents mentioned that a change in management at a vendor can potentially cause problems. One respondent stated that maintaining partnerships is important for completion of the work and constant turn-over stands in the way of this. Likewise, all respondents stated that the bankruptcy of a vendor is a great concern. The bankruptcy proceedings of a vendor sometimes come as a surprise and can pose significant risk and operating challenges to the airline. In addition to the difficulty of re-possessing company property at the vendor, often times the FAA revokes the certificate of the repair station and causes the work that has already been completed by the repair station to be re-inspected.

On the other hand, extensive growth at a vendor is of concern to six of the respondents. One respondent suggested that problems from extensive growth will likely reflect in the quality of the work. Another respondent suggested that this may be due primarily to new personnel who may not be experienced as existing personnel. There might be paperwork problems as well.

When it is time to renew a contract with a vendor, all of the same criteria used in the initial decision to award the original contract apply. However, one respondent pointed out that in the renewal process there is an experience base from which to work, and that the airline is in a greater position to deal with concerns. Cost becomes less of an issue when renewing a contract as there is already an established relationship between the vendor and the airline.

Two respondents stated that they have never terminated a contract. The respondents offered several reasons for terminating contracts. These include flagrant quality problems, longer cycle times than originally stipulated in the contract, or that the vendor exceeded their capabilities.

## 4.6 Oversight by Other Entities

Most respondents felt that the industry alphabet groups, such as the Air Transport Association (ATA) and the Regional Airline Association (RAA) did not necessarily provide a forum with which to discuss issues related to outsourcing maintenance. Two respondents

did say that they have gleaned general maintenance information at operators' conferences that were in some cases sponsored by the alphabet groups.

Four respondents stated they belong to CASE, while one respondent was previously an associate member. Most CASE respondents used CASE audits, but only supplemental to their own. One respondent said that they report any violations by a repair station or any contract terminations to CASE. While all respondents accepted CASE audits as a standard, they also mentioned that they usually went over and above those standards for their own internal purposes.

All respondents reported that there was very little coordination between the PMI of the vendor and the airline. The only communication that generally occurs is in the case of a problem. No respondent said that they were involved when FAA conducts inspection of a vendor. Most respondents are not notified when FAA revokes a Part 145 certificate of a vendor.

# 5. Development of Performance Measures

## 5.1 Introduction

Performance measures provide the means to rate the effectiveness of an operation. In the context of this study, the performance measures should provide a means to evaluate certain sections of repair station operation. Ideally, the performance measures are actually data that is already part of the FAA inspection process or can be gathered from readily available sources.

The analysis presented in the previous chapter provides the basis for developing the performance measures. First, the different areas of the repair station operation are identified that the respondents said that they consider when seeking bids for work and subsequently monitor while a repair station is under contract. Specific points are then identified that are indicative of performance under each area. These points can then be "translated" into performance measures.

## 5.2 Identification of Performance Measures for Repair Station Operation

The interview results yielded three primary reasons an airline outsources to a repair station. These include less turnaround time to complete a particular task, lower and/or fixed cost, and less investment in labor and/or capital equipment (i.e., tooling, test equipment).

One respondent noted that if managed correctly, a repair station functions as if it is simply another division of the airline. In order to achieve this goal, the repair station must conform to the procedures and standards set for by the airline, which is required by FAA regulation. Likewise, the airline must provide the proper documentation and support in order for this arrangement to occur effectively. To ensure this is the case, the airline must spend a great deal of time and effort to manage the relationship between itself and the repair station and monitor the progress and outcome of the work performed by the repair station.

Based on the analysis, the points of the repair station operation that the respondents monitored can be categorized under three areas: capabilities, performance, and administration. Each area is discussed in greater detail.

### 5.2.1 Capabilities of Repair Station Operation

Obviously, it is important for a repair station to be able to deliver what was promised in its contracts. In other words, the repair station must actually possess the capabilities to deliver the services it says and is certified to perform. One respondent mentioned that while comparing bids for a contract that the evaluation of the bids focussed on whether or not the repair station is operating within their capabilities. While most respondents stated that reputation guides this judgement, there are several points that can be measured to ensure that repair stations are operating within their capabilities.

In order for repair stations to operate within their capabilities, there are three components that can vary: labor, capital equipment, and certification of the repair station itself. Labor can vary in terms of number, years of experience, certifications, and qualifications. Labor may also be contracted from temporary labor services. All of these variables affect the performance of the work. Capital equipment can vary by the tooling and test equipment that the repair station possesses. In some cases, FAR Part 145 clearly details what a repair station must possess. The regulation also explicitly states that personnel who operate this equipment must be properly trained. In terms of certification, the repair station must possess the proper rating to perform the work that they advertise as able to do. Ratings vary by aircraft types as well as particular sections of the aircraft.

Based on this scheme, Table 5.1 identifies performance measures that quantify the capabilities of a repair station. The table includes the variable or unit that can be used as a data source, the significance of the performance measure related to repair station capabilities, the FAR Part 145 reference for the performance measure, and the desirable range of values for the performance measure. Complete FAR Part 145 references are listed in Appendix C.

**Table 5.1. Performance Measures for Repair Station Capabilities**

| Performance Measure | Variable/ Unit | Significance | FAR Ref. | Range |
|---|---|---|---|---|
| Contract employees | Number | Possible lack of experience, training | 145.43 | <100% |
| Certificated employees | Number | Denotes qualification to legally perform work | 145.43/ 65.89 | >0% |
| Experience of employees | Average | Denotes expertise in area, stability of workforce | 145.43 | >1 |
| Training of employees | List | Indicates qualifications of employees | 145.43 | Must reflect work actually performed |
| Certification infractions | Number | Indicates repair station operating outside of its capabilities | 145.31; 145.33 | <1 |
| Total number of employees | Number | Indicates ability to perform workload | 145.39b | >0 |
| Tools and test equipment | List | Capability to legally perform work | 145.49; 145.39 | >0 |
| Ratings | Number | Ability to legally perform work | 145.31; 145.33 | >0 |

Most of these performance measures are based upon readily available data. Some of the data is already collected as part of FAA inspections.

### 5.2.2 Performance of Repair Station Operation

Performance of repair station operation refers to the quality of work the repair station produces. While capabilities focus on what it *is possible* for the repair station to do, performance focuses on what the repair station *actually does*. At a higher level, these attributes of a repair station is actually what the airlines monitor the most.

Based on this scheme, Table 5.2 lists performance measures that relate to how well a repair station delivers on its work. The table includes the variable or unit that can be used as a data

source, the significance of the performance measure related to repair station performance, the FAR Part 145 reference for the performance measure, and the desirable range of values for the performance measure. Complete FAR Part 145 references are listed in Appendix C.

**Table 5.2. Performance Measures for Repair Station Performance**

| Performance Measure | Variable/ Unit | Significance | FAR Ref. | Range |
|---|---|---|---|---|
| Audit procedures in place | Y/N | Ability to detect and rectify errors in work | 145.59; 145.63 | Must reflect work peformed |
| Ability to meet turn times | Time diff. | May indicate working outside of capabilities | N/A | <1 |
| Number of discrepancies | Number | May indicate poor performance | 145.2 | <1 |
| Bogus part infractions | Number | Indicates poor suppliers of parts and parts tracking. | 145.45 | <1 |

Data to support these performance measures may be more difficult to obtain in some cases. Many of these items are measured strictly by the airline and are considered proprietary information by both the airline and the repair station. In this case, it is unlikely that this data would be made publicly available or even to the FAA.

### 5.2.3 Performance of Repair Station Administration

Administration of a repair station refers to the overall organization and operation of the repair station. Management is also included under this category.

Based on this scheme, Table 5.3 lists performance measures that relate to repair station administration. The table includes the variable or unit that can be used as a data source, the significance of the performance measure related to repair station administration, the FAR Part 145 reference for the performance measure, and the desirable range for the performance measure. Complete FAR Part 145 references are listed in Appendix C.

**Table 5.3. Performance Measures for Repair Station Administration**

| Performance Measure | Variable/ Unit | Significance | FAR Ref. | Range |
|---|---|---|---|---|
| Discrepancies in billing | Number | Lack of attention to paperwork in other areas | N/A | >1 |
| Financial Status | Y/N | Bankruptcy is a problem; may indicate other larger problems | N/A | N |
| New employees | Number | Denotes growth of company; indicate potential training gaps | N/A | Must reflect actual work performed |
| Change in management | Y/N | May indicate change in procedures and focus of operations | 145.43 | N |
| Termination of Contracts | Number | Possible inability to keep up with work | N/A | >1 |

The data to support these performance measures will mostly be obtained from data sources outside current FAA inspections.

## 5.3 Identification of Performance Measures for Airlines with Major Contracts with Repair Stations

As stated previously, the airline contracting a repair station for a major contract cannot simply state the specifications for the work and expect for it to be completed in a satisfactory manner. The airline usually provides a fair amount of support in order to ensure proper completion of the job.

In analyzing the interview responses, it is apparent that there are certain actions that airlines take when outsourcing major maintenance. These primarily deal with how the airline provides oversight of the functions the repair station has been contracted to perform.

Table 5.4 lists the performance measures that are related to the airlines that may have an impact with repair station performance. The table includes the variable or unit that can be used as a data source, the significance of the performance, the FAR Part 145 reference for the performance measure, and the desirable range of the performance measure. Complete FAR Part 145 references are listed in Appendix C.

**Table 5.4. Performance Measures for Airlines with Major Contracts with Repair Stations**

| Performance Measure | Variable/ Unit | Significance | FAR Ref. | Range |
|---|---|---|---|---|
| Percent Outsourced Maintenance | $; cost/ ASM | Increased outsourced maintenance requires different organization structure | Form 41 | Varies with type of work |
| Company personnel at a repair station | Number | Airline oversight of operation | N/A | Reflected in type of work; >0 |
| Use of foreign repair station | Y/N | Requires "special" oversight | N/A | Y/N |

The data to support these performance measures can be gathered relatively easily. The percent outsourced maintenance figures must be filed with the Department of Transportation. The other information may be obtained by inspections.

## 5.4 Performance Measures of Marginal Importance

There are some attributes that respondents claimed that were not of great importance to them, at least superficially. Table 5.5 details the list of these performance measures. Note that even though some of the performance measures are referenced in FAR Part 145, they are still not considered of primary importance to the respondents.

**Table 5.5. Performance Measures for Repair Stations of Marginal Importance**

| Performance Measure | Variable/ Unit | Significance | FAR Ref. | Range |
|---|---|---|---|---|
| Wages | $; avg. | Lower wage, lower quality | N/A | N/A |
| Security Measures | List | Possible security breach | 145.35 | N/A |
| Employee turnover | Avg. exp Number of new emp. | May indicate lack of experience in certain areas | 145.33 | N/A |

# 6. Summary and Additional Research

## 6.1 Summary

The interview that was developed during the course of this study sought to collect information about the process of outsourcing maintenance in the airline industry. The data that was collected identified the most common criteria that the respondents used to select, monitor, and assess the performance of their 3PMPs. Using this criteria, performance measures were developed that rate repair station capabilities, performance, and administration.

The performance measures still require refinement. The availability of data and applicability to Flight Standards' analysis (e.g., desired range of values of each performance measure) will require further investigation. It is expected that FAA personnel involved with this study and other researchers will assist in this refining process.

## 6.2 Related Research Efforts

### 6.2.1 FAA Efforts

A recently completed study by Goldsby performed under grant for the Office of Aviation Medicine and Flight Standards Service of FAA reports on the operational and regulatory challenges faced by "third party" (3rd Party), or contract repair stations, that provide intermediate and heavy level airframe maintenance for FAR Part 121 certificated air carriers. The executive summary follows:

Current operations, personnel, human factors, training, qualifications, documentation processes, job/task sign off issues and problems were examined. FAA oversight, surveillance and inspection of these operations were also reviewed. In addition, the relationships between aircraft operators (air carriers) and their contract maintainers were evaluated for potential issues and problems.

This research was accomplished by visiting major repair station sites and FSDOs over a cross section of the country. Altogether seven repair stations and FSDOs were visited, and over sixty people were interviewed. The researchers met and spoke with groups and individuals at the operations level of both major repair stations and the FAA. The findings and this report are based on those discussions and observations. By design, the research method and reports is not meant to be a statistical analysis. Instead, it is a "grass roots" investigation of what is actually going on in the day-to-day operation of the domestic 3rd Party contract maintenance business.

Oversight of 3rd Party contract maintenance has improved dramatically since the ValuJet accident in May of 1996. A United States GAO report to Congressional Requesters, entitled *Aviation Safety -- FAA Oversight of Repair Stations Needs Improvement*, was released in October of 1997 and was critical of the FAA's inspection and oversight of 3rd Party repair stations. Several recommendations were made based upon the GAO's findings and evaluation. The majority of these recommendations relating to inspection and oversight of

repair stations have been implemented by the FAA; some were in progress prior to the report being distributed, others have been accomplished, some are still in various stages of implementation.

The inspection and oversight process is working well. FAA field operations are accomplishing the objective of ensuring that aviation maintenance is being carried out safely within the established rules and regulations. Air carriers and repair stations are ensuring that the air carrier's manuals, task documentation, procedures and processes are being followed. The relationships between the FAA field operations staff, PMIs, the Aviation Safety Inspectors (ASIs), with some rare exceptions, are generally good to excellent. Are there issues and challenges within this process? Can improvements be made? Are there some problems and challenges that need to be addressed? The answer to these questions is, yes. However, the system is functioning well, continuously improving, and working to ensure regulatory compliance and aviation safety in the various maintenance facets of the industry.

The issues and problems that do exist are primarily systemic, having to do with the clarity and uniformity of FAA's management processes and oversight. These opportunities for regulatory improvement range from internal communications, varied interpretation of rules and regulations, autonomy of Regions and Flight Standards District Offices (FSDOs), and the evolving regulatory review and change process. It creates a climate where many in industry feel they must constantly struggle to conduct business in this sometimes strained and ill-defined environment. These factors and non-uniform oversight situations have the potential to drive up the cost of doing business at an aircraft maintenance facility. Further they can lead to inefficient and costly regulatory oversight.

It is apparent that significant changes have been made based upon the lessons learned from the ValuJet accident. The errors made that caused the system to breakdown and created the chain of events that contributed to this accident have been addressed, eliminated, and/or corrected. However, there are no guarantees that the changes made, along with the increased level, frequency, and improved quality of FAA oversight and inspections will prevent such an accident from occurring again.

Despite these changes, there is much that remains to be done to update the FAA's operations systems, processes, and internal communications. There has been little progress to streamline the regulatory change and review process. Other nations are able to make significant progress in the area of regulatory change while the US has moves very slowly with maintenance regulatory action. Determining how to address and solve the existing issues and problems is not a simple task. Political oversight and special action committees have not been effective at changing rules. FAA continues to apply its limited appointed and career staff to identify and solve challenges that are presented in this report.

### 6.2.2 NTSB Efforts

In addition, The National Transportation Safety Board conducted a public forum to examine air carrier and Federal Aviation Administration oversight of contract repair stations that provide aviation maintenance. A summary of the forum follows:

Air carrier operators, maintenance repair facilities, and the Federal Aviation Administration (FAA) all have responsible roles to ensure the airworthiness of an aircraft that has undergone heavy maintenance at a Part 145 contract repair facility. Technical specialists representing each of these players will participate in a 1-day public forum to discuss the oversight practices that are used to ensure work quality and airworthiness. The forum will be organized around three technical panels, composed of 3-4 participants each.

Since the investigation of the ValuJet accident in the Everglades near Miami, Florida (1996), the Safety Board has been increasingly concerned with air carrier and FAA oversight of contract maintenance repair stations. The public forum will examine the oversight practices used by both the FAA and the air carriers to ensure the quality of inspection and maintenance work performed by contract repair stations.

Several industry factors are affecting airline maintenance operations in general and contract maintenance practices in particular. First, many airplanes are being kept in service beyond their original design life and therefore have increased maintenance requirements. Second, route structures associated with hub and spoke operations have increased the number of takeoffs and landings cycles, which in turn, increases the maintenance requirements. Third, as a result of competitive market pressures in the airline business, large, well-established airlines, as well as small, start-up airlines have found it necessary to outsource more maintenance to Part 145 repair stations. It is now estimated that nearly half of all aviation maintenance is preformed by contract repair stations.

The public forum addressed: (1) air carrier maintenance operating procedures for quality control and oversight of outsourced maintenance services; (2) assessment processes used by Part 145 repair stations to ensure the quality of maintenance work; (3) FAA inspection and oversight of contract maintenance work, including procedures for inspections, reporting, deficiency tracking, and general oversight of repair operations; (4) and, the status of FAA's implementation of its new inspection program, Air Transportation Oversight System (ATOS), and the information tools associated with that program, such as the On-Line Aviation Safety Inspection System (OASIS).

## 6.3 Plans for Further Investigation

The results of the interviews already conducted have raised additional issues and identified areas requiring more in-depth investigation. The proposed research will focus on gathering more information about these topics. A partial list of the areas of interest includes:

- Structure and effectiveness of parts reliability programs,
- Structure and effectiveness of parts scrapping programs,
- Certificated versus non-certificated labor at repair stations,
- Structure and effectiveness of suspected unapproved parts programs,
- Opinions regarding FAA inspections,
- Identification of FAA information desired by the industry,
- Identification of desired improvements in information dissemination within the industry,

- Identification and comparison of services provided by repair stations,
- Relationships with foreign and Canadian repair stations and related performance.

A selection of topics will be chosen from this list by members of the research staff in cooperation with the FAA. Additional topics of mutual interest may also be identified. The previously developed interview process will be revised to accommodate the expanded list of topics.

Respondents from the airlines that have already participated in this research effort will be contacted once again to answer the additional questions. Also, research staff will also contact three to four additional airlines to expand the already existing sample. Specifically, at least one of these airlines will be a foreign operator.

To gain additional perspective on the issues being researched, repair stations will also be included in the sample. The interview questions will be adapted as appropriate. Three to four repair stations, foreign and domestic, will be contacted to participate in this study. Specifically, at least one of these repair stations will be a Canadian aircraft maintenance organization.

The additional information collected from both the airlines and the repair stations will be used to enhance the performance measures already developed and to also identify new performance measures as well. In addition, this effort may serve as a basis to identifying additional data requirements related to repair station inspections. The research staff will coordinate with other FAA-related efforts underway as necessary.

# Appendix A – Bibliography


Booz-Allen & Hamilton. (1994). "A Survey of Airline Maintenance Benchmarks." Booz-Allen & Hamilton, San Francisco, CA.

Cala, J., and Bond, R. (1993). "Maintaining a Lead." Airline Business, 42-45.

Condom, P. (1994). "Is Outsourcing the Winning Solution." Interavia, 34-38.

DeLauro, A. A. (1994). "Changing Customer and Supplier Strategies in Third-Party Maintenance." Aircraft Economics, 43-44.

Feldman, J. M. (1992). "Airlines Lighten the Load." Air Transport World, 32-36.

Gallacher, J. (1999). "Third Party Pressure." Airline Business, 48-50.

Hill, L. (1996). "Lufthansa Technik in China." Air Transport World, 67-69.

McKenna, J. T., and Scott, W. B. (1997). "MRO's Challenge: Quality vs. Cost." Aviation Week & Space Technology, 44-45.

O'Mahony, C. (1992). "Optimizing Maintenance Costs." Airfinance Journal, xix-xvii.

Phillips, E. H. (1996). "Outsourcing Emerges as Key MRO Trend." Aviation Week & Space Technology, 42-44.

Phillips, E. H., and Mann, P. (1996). "FAA Tightens Airline Inspections." Aviation Week & Space Technology, 22-23.

Reed, A. (1991). "Maintenance: Facing Up to the M&E Shortage." Air Transport World, 64.

Reed, A. (1998). "The Elusive Mechanic." Air Transport World, 26-34.

Sparaco, P. (1996). "Outsourcing Kindles Technical Debate." Aviation Week & Space Technology, 89.

United States. General Accounting Office. (1990). *Aircraft Maintenance: Potential Shortage in National Aircraft Repair Capacity*, General Accounting Office, Washington, D.C.

United States. General Accounting Office. (1995). *Aviation Safety: Data Problems Threaten FAA Strides on Safety Analysis System*, General Accounting Office, Washington, D.C.

United States. General Accounting Office. (1997). *Aviation Safety: FAA Oversight of Repair Stations Needs Improvement*, General Accounting Office, Washington, D.C.

United States. General Accounting Office. (1999). *Aviation Safety: FAA's New Inspection System Offers Promise, but Problems Need to be Addressed*, General Accounting Office, Washington, D.C.

Vandyk, A. (1996). "The Low Cost of Quality." Air Transport World, 168.

Warwick, G. (1998). "Muscling to the Market Lead." Flight International, 31-50.

Williams, C. (1994a). "Scale and Control: The Name of the Game in Engine Overhaul." Aircraft Economics, 32-37.

Williams, C. (1994b). “To Maintain or Not to Maintain, That is the Question.” Aircraft Economics, 37-41.

# Appendix B – Interview Outline

**Background Information**

Size of Maintenance Operation

- What is your total maintenance budget?
  - How is the budget subdivided?
  - For line service?
  - For scheduled checks?
  - For routine maintenance?
  - For non-routine maintenance?

- What are the areas of major expenditures?
  - What does 80% of your budget consist of?
  - What percentage of the total budget is the maintenance budget?

- What percent of the maintenance budget is outsourced?

- Is there a limit as to how much maintenance can be outsourced?
  - If so, what is the limit, and who set it?

Typical maintenance functions outsourced

- Which functions are likely to be outsourced?
  - Line service
  - Scheduled checks
    - Light (A,B)
    - Heavy checks (C,D)
  - Component/System Overhaul
  - Engine
  - Others?
- Why are these functions outsourced?
  - Cost?
  - Special equipment/tooling required?
  - Special labor skills?
  - Others?

Outsourcing providers

- What kinds of providers do you employ?
  - Repair Stations?
  - Component shops?
  - FBOs?
  - Other airlines?
  - Others?

**Criteria for Third Party Maintenance Providers**

Identifying potential providers

How do you identify potential providers?
- Research?
- CASE Audit?
- Advertisements?
- Request for bid?
- Interview/site visits?

Who do you consider the top-rated providers?
- For line service?
- For component overhaul?
- For engine shops?
- For heavy checks?
- Others?

Do you consider foreign repair stations the same as domestic ones?
- What are the differences between foreign and domestic repair stations?
- Do they require special oversight on your part?

Requirements of provider

Do you require special insurance coverage as part of the contract?

Do you consult the principal maintenance inspector of a potential provider?
- What type of information do you ask them?
- FAA actions?

Do you consider the make-up of the workforce?
- Union versus nonunion?
- If a school is connected to the provider?
- Certificated versus uncertificated?
- Percentage of certificated employees?
- Specialization (repairmen certificates)?
- Employee turnover?
- Workload?
- Wages?

How are regulations considered?
- EPA?
- OSHA?

What factors are considered for the aircraft while on site of the provider?
- Does the aircraft have to be kept in a hangar or can the work be performed outside?

Is security an issue?

Do you consider the financial status of the provider?
Credit check?
Solvency?

Requirements of contractor

Does the potential provider have any requirements of the contractor?
On-site personnel?
Documentation of aircraft?
Documentation of procedures?

Decision making process

What are the most important criteria in comparing bids from providers?
Cost
Performance
Guarantees

**Awarding contracts**

When a contract is awarded, what language is written into the contract to ensure performance of the provider?

What is the typical period of performance?

Number of aircraft the contract covers?

Is the contract ever modified?

**Monitoring and Assessing Performance**

Company Issues

How important is it to you if a contract maintenance facility is undergoing
a change in management?
bankruptcy proceedings?
extensive growth?

Personnel

Are company personnel on-site at the third party provider?
If so, how large is the contract?
How many personnel?
Who are the personnel on-site?
Are the personnel on-site company employees?
What is their function while on-site?

If not, how is performance monitored?

Performance Measures

What data is collected from the provider, about the provider while under contract?

Physical/service oriented?
Economic?
Personnel?
Workload?
FAA actions?

What data would be useful to have, but is not collected?

What data is considered proprietary?

Which of the criteria used in deciding to award the contract to the provider is still monitored while the provider is under contract?

What documentation is required while the provider is under contract?

About the aircraft?
About procedures?
About compliance with company set policies?
About compliance with FAA regulations?
Other?

In what format is this documentation delivered?

Paper?
Electronic?
Other?

How is quality assurance monitored while the aircraft (or components of the aircraft) is at the facility of the provider?

How do you ensure proper materials are being used?
How do you ensure against suspected unapproved parts?
How do you ensure that established procedures are being followed?

Is the work of a provider audited?

If so, how?

Are there any special inspections or procedures that are completed after the aircraft has returned from the provider?

How is post delivery performance monitored?

Renewal of contract

What criteria are most important to evaluate when renewing a contract?

What criteria are least important when renewing a contract?

Termination of contract

For what reasons are a contract terminated?

Is a contract termination reported to the FAA or any other entity?

**Oversight by Other Entities**

CASE

How much do you rely on CASE audits for information about the performance of a third party provider?

What information do you still collect on your own?

Industry Groups

Do industry groups provide any guidance regarding outsourcing maintenance?

Do industry groups provide a forum in which to share information about repair stations and other third party providers?

FAA

How do you ensure compliance with FAA regulations?

Do you coordinate with the local PMI of the provider?

How are you involved if the FAA is conducting a routine or non-routine inspection of the providers facility?

Are you notified if the FAA pulls/revokes/suspends a 145 certificate? If yes, how soon?

# Appendix C – FAR Part 145 References

Sec. 145.2 Performance of maintenance, preventive maintenance, alterations and required inspections for an air carrier or commercial operator under the continuous airworthiness requirements of Parts 121 and 127, and for airplanes under the inspection program required by Part 125.

(a) Each repair station that performs any maintenance, preventive maintenance, alterations, or required inspections for an air carrier or commercial operator having a continuous airworthiness program under Part 121 or Part 127 of this chapter shall comply with Subpart L of Part 121 (except Secs. 121.363, 121.369, 121.373, and 121.379) or Subpart I of Part 127 (except Secs. 127.131, 127.134, 127.136, and 127.140) of this chapter, as applicable. In addition, such repair station shall perform that work in accordance with the air carrier's or commercial operator's manual.

(b) Each repair station that performs inspections on airplanes governed by Part 125 of this chapter shall do that work in accordance with the inspection program approved for the operator of the airplane.

[Amdt. 145-7, 31 FR 10614, Aug. 9, 1966, as amended by Amdt. 145-17, 45 FR 67235, Oct. 9, 1980]

Sec. 145.31 Ratings.

The following ratings are issued under this subpart:

(a) Airframe ratings. (1) Class 1: Composite construction of small aircraft.

(2) Class 2: Composite construction of large aircraft.

(3) Class 3: All-metal construction of small aircraft.

(4) Class 4: All-metal construction of large aircraft.

(b) Powerplant ratings. (1) Class 1: Reciprocating engines of 400 horsepower or less.

(2) Class 2: Reciprocating engines of more than 400 horsepower.

(3) Class 3: Turbine engines.

(c) Propeller ratings. (1) Class 1: All fixed pitch and ground adjustable propellers of wood, metal, or composite construction.

(2) Class 2: All other propellers, by make.

(d) Radio ratings. (1) Class 1: Communication equipment: Any radio transmitting equipment or receiving equipment, or both, used in aircraft to send or receive communications in flight, regardless of carrier frequency or type of modulation used; including auxiliary and related aircraft interphone systems, amplifier systems, electrical or electronic inter-crew signaling devices, and similar equipment; but not including equipment used for

navigation of the aircraft or as an aid to navigation, equipment for measuring altitude or terrain clearance, other measuring equipment operated on radio or radar principles, or mechanical, electrical, gyroscopic, or electronic instruments that are a part of communications radio equipment.

(2) Class 2: Navigational equipment: Any radio system used in aircraft for en route or approach navigation, except equipment operated on radar or pulsed radio frequency principles, but not including equipment for measuring altitude or terrain clearance or other distance equipment operated on radar or pulsed radio frequency principles.

(3) Class 3: Radar equipment: Any aircraft electronic system operated on radar or pulsed radio frequency principles.

(e) Instrument ratings. (1) Class 1: Mechanical: Any diaphragm, bourdon tube, aneroid, optical, or mechanically driven centrifugal instrument that is used on aircraft or to operate aircraft, including tachometers, airspeed indicators, pressure gauges drift sights, magnetic compasses, altimeters, or similar mechanical instruments.

(2) Class 2: Electrical: Any self-synchronous and electrical indicating instruments and systems, including remote indicating instruments, cylinder head temperature gauges, or similar electrical instruments.

(3) Class 3: Gyroscopic: Any instrument or system using gyroscopic principles and motivated by air pressure or electrical energy, including automatic pilot control units, turn and bank indicators, directional gyros, and their parts, and flux gate and gyrosyn compasses.

(4) Class 4: Electronic: Any instruments whose operation depends on electron tubes, transistors, or similar devices including capacitance type quantity gauges, system amplifiers, and engine analyzers.

(f) Accessory ratings. (1) Class 1: Mechanical accessories that depend on friction, hydraulics, mechanical linkage, or pneumatic pressure for operation, including aircraft wheel brakes, mechanically driven pumps, carburetors, aircraft wheel assemblies, shock absorber struts and hydraulic servo units.

(2) Class 2: Electrical accessories that depend on electrical energy for their operation, and generators, including starters, voltage regulators, electric motors, electrically driven fuel pumps magnetos, or similar electrical accessories.

(3) Class 3: electronic accessories that depend on the use of an electron tube transistor, or similar device, including supercharger, temperature, air conditioning controls, or similar electronic controls.

Sec. 145.33 Limited ratings.

(a) Whenever the Administrator finds it appropriate, he may issue a limited rating to a domestic repair station that maintains or alters only a particular type of airframe, powerplant, propeller, radio, instrument, or accessory, or parts thereof, or performs only specialized maintenance requiring equipment and skills not ordinarily found in regular repair

stations. Such a rating may be limited to a specific model aircraft, engine, or constituent part, or to any number of parts made by a particular manufacturer.

(b) Limited ratings are issued for--

(1) Airframes of a particular make and model;

(2) Engines of a particular make and model;

(3) Propellers of a particular make and model;

(4) Instruments of a particular make and model;

(5) Radio equipment of a particular make and model;

(6) Accessories of a particular make and model;

(7) Landing gear components;

(8) Floats, by make;

(9) Nondestructive inspection, testing, and processing;

(10) Emergency equipment;

(11) Rotor blades, by make and model;

(12) Aircraft fabric work; and

(13) Any other purpose for which the Administrator finds the applicant's request is appropriate.

(c) For a limited rating for specialized services, the operations specifications of the station shall contain the specification used in performing that specialized service. The specification may either be a civil or military one that is currently used by industry and approved by the Administrator or one developed by the applicant and approved by the Administrator.

Sec. 145.35 Housing and facility requirements.

(a) An applicant for a domestic repair station certificate and rating, or for an additional rating, must comply with paragraphs (b) to (h) of this section and provide suitable--

(1) Housing for its necessary equipment and material;

(2) Space for the work for which it seeks a rating;

(3) Facilities for properly storing, segregating, and protecting materials, parts, and supplies; and

(4) Facilities for properly protecting parts and subassemblies during disassembly, cleaning, inspection, repair, alteration, and assembly;

so that work being done is protected from weather elements, dust, and heat; workers are protected so that the work will not be impaired by their physical efficiency; and maintenance operations have efficient and proper facilities.

(b) The applicant must provide suitable shop space where machine tools and equipment are kept and where the largest amount of bench work is done. The shop space need not be partitioned but machines and equipment must be segregated whenever--

(1) Machine or woodwork is done so near an assembly area that chips or

material might inadvertently fall into assembled or partially assembled work;
(2) Unpartitioned parts cleaning units are near other operations;
(3) Fabric work is done in an area where there are oils and greases;
(4) Painting or spraying is done in an area so arranged that paint or paint dust can fall on assembled or partially assembled work;
(5) Paint spraying, cleaning, or machining operations are done so near testing operations that the precision of test equipment might be affected; and
(6) In any other case the Administrator determines it is necessary.
(c) The applicant must provide suitable assembly space in an enclosed structure where the largest amount of assembly work is done. The assembly space must be large enough for the largest item to be worked on under the rating he seeks and must meet the requirements of paragraph (a) of this section.
(d) The applicant must provide suitable storage facilities used exclusively for storing standard parts, spare parts, and raw materials, and separated from shop and working space. He must organize the storage facilities so that only acceptable parts and supplies will be issued for any job, and must follow standard good practices for properly protecting stored materials.
(e) The applicant must store and protect parts being assembled or disassembled, or awaiting assembly or disassembly, to eliminate the possibility of damage to them.
(f) The applicant must provide suitable ventilation for his shop, assembly, and storage areas so that the physical efficiency of his workers is not impaired.
(g) The applicant must provide adequate lighting for all work being done so that the quality of the work is not impaired.
(h) The applicant must control the temperature of the shop and assembly area so that the quality of the work is not impaired. Whenever special maintenance operations are being performed, such as fabric work or painting, the temperature and humidity control must be adequate to insure the airworthiness of the article being maintained.

Sec. 145.39 Personnel requirements.

(a) An applicant for a domestic repair station certificate and rating, or for an additional rating, must provide adequate personnel who can perform, supervise, and inspect the work for which the station is to be rated. The officials of the station must carefully consider the justifications and abilities of their employees and shall determine the abilities of its uncertificated employees performing maintenance operations on the basis of practical tests or employment records. The repair station is primarily responsible for the satisfactory work of its employees.
(b) The number of repair station employees may vary according to the type and volume of its work. However, the applicant must have enough properly

qualified employees to keep up with the volume of work in process, and may not reduce the number of its employees below that necessary to efficiently produce airworthy work.

(c) Each repair station shall determine the abilities of its supervisors and shall provide enough of them for all phases of its activities. However, the Administrator may determine the ability of any supervisor by inspecting his employment and experience records or by a personal test. Each supervisor must have direct supervision over working groups but need not have over-all supervision at management level. Whenever apprentices or students are used in working groups on assemblies or other operations that might be critical to the aircraft, the repair station shall provide at least one supervisor for each 10 apprentices or students, unless the apprentices or students are integrated into groups of experienced workers.

(d) Each person who is directly in charge of the maintenance functions of a repair station must be appropriately certificated as a mechanic or repairman under Part 65 of this chapter and must have had at least 18 months of practical experience in the procedures, practices, inspection methods, materials, tools, machine tools, and equipment generally used in the work for which the station is rated. Experience as an apprentice or student mechanic may not be counted in computing the 18 months of experience. In addition, at least one of the persons so in charge of maintenance functions for a station with an airframe rating must have had experience in the methods and procedures prescribed by the Administrator for returning aircraft to service after 100-hour, annual, and progressive inspections.

(e) Each limited repair station shall have employees with detailed knowledge of the particular maintenance function or technique for which it is rated, based on attending a factory school or long experience with the product or technique involved.

Sec. 145.43 Records of supervisory and inspection personnel.

(a) Each applicant for a domestic repair station certificate and rating, or for an additional rating, must have, and each certificated domestic repair station shall maintain, a roster of--

(1) Its supervisory personnel, including the names of the officials of the station that are responsible for its management and the names of its technical supervisors, such as foreman and crew chiefs; and

(2) Its inspection personnel, including the names of the chief inspector and those inspectors who make final airworthiness determinations before releasing an article to service.

(b) The station shall also provide a summary of the employment of each person whose name is on the roster. The summary must contain enough information as to each person on the roster to show compliance with the experience requirements of this subpart, including--

(1) His present title (e.g., chief inspector, metal shop foreman, etc.);

(2) His total years of experience in the type of work he is doing;
(3) His past employment record, with names of places and term of employment by month, and year;
(4) The scope of his present employment (e.g., airframe overhaul, airframe final assembly, engine inspection, department, etc.); and
(5) The type and number of the mechanic or repairman certificate that he holds, and the ratings on that certificate.
(c) The station shall change the roster, as necessary, to reflect--
(1) Terminating the employment of any person whose name is on the roster;
(2) Assigning any person to duties that require his name to be carried on the roster; or
(3) Any appreciable change in the duties and scope of assignment of any person whose name is on the roster.
(d) The station shall keep the roster and employment summaries required by this section, subject to inspection by the Administrator upon his request.
(e) A domestic repair station may not use the services of a person directly in charge of maintenance or alteration unless it keeps current records on him as required by this section.

[Doc. No. 1157, 27 FR 6662, June 13, 1962, as amended by Amdt. 145-5, 31 FR 8585, June 21, 1966; Amdt. 145-15, 41 FR 47230, Oct. 28, 1976]

Sec. 145.49 Equipment and materials: Limited rating.

(a) An applicant for a limited rating (other than specialized services) under Sec. 145.33, must have the equipment and materials to perform any job function appropriate to the rating and class specified in Sec. 145.47 for the rating he seeks. However, he need not be equipped for a function that does not apply to the particular make or model article for which he seeks a rating, if he shows that it is not necessary under the recommendations of the manufacturer of the article.
(b) An applicant for a rating for specialized services or techniques under Sec. 145.33 must--
(1) For magnetic and penetrant inspection, have the equipment and materials for wet and dry magnetic inspection techniques, residual and continuous methods, and portable equipment for the inspection of welds both on and off the aircraft;
(2) For emergency equipment maintenance, have the equipment and materials to perform inspections, repairs, and tests of all kinds of inflated equipment, the re-packing, re-marking, re-sealing, and re-stocking of life rafts, and the weighing, refilling, and testing of carbon dioxide fire extinguishers and oxygen containers;
(3) For rotor blade maintenance, have the equipment, materials, and technical data recommended by the manufacturer; and
(4) For aircraft fabric work, have the equipment and materials to apply protective coatings to structures, machine stitch fabric panels, perform

covering, sewing, and rib stitching operations, apply dope and paint using temperature and humidity control equipment, install patches, grommets, tapes, hooks, and similar equipment, and refinish entire aircraft and aircraft parts.

Sec. 145.45 Inspection systems.

(a) An applicant for a repair station certificate, and rating or for an additional rating, must have an inspection system that will produce satisfactory quality control and conform to paragraphs (b) to (f) of this section.

(b) The applicant's inspection personnel must be thoroughly familiar with all inspection methods, techniques, and equipment used in their specialty to determine the quality or airworthiness of an article being maintained or altered. In addition, they must--

(1) Maintain proficiency in using various inspection aids intended for that purpose;

(2) Have available and understand current specifications involving inspection tolerances, limitations, and procedures established by the manufacturer of the product being inspected and with other forms of inspection information such as FAA airworthiness directives and bulletins; and

(3) In cases where magnetic, fluorescent, or other forms of mechanical inspection devices are to be used, be skilled in operating that equipment and be able to properly interpret defects indicated by it.

(c) The applicant must provide a satisfactory method of inspecting incoming material to insure that, before it is placed in stock for use in an aircraft or part thereof, it is in a good state of preservation and is free from apparent defects or malfunctions.

(d) The applicant must provide a system of preliminary inspection of all articles he maintains to determine the state of preservation or defects. He shall enter the results of each inspection on an appropriate form supplied by it and keep the form with the article until it is released to service.

(e) The applicant must provide a system so that before working on any airframe, powerplant, or part thereof that has been involved in an accident, it will be inspected thoroughly for hidden damage, including the areas next to the obviously damaged parts. He shall enter the results of this inspection on the inspection form required by paragraph (d) of this section.

(f) At the time he applies for a repair station certificate, the applicant must provide a manual containing inspection procedures, and thereafter maintain it in current condition at all times. The manual must explain the internal inspection system of the repair station in a manner easily understood by any employee of the station. It must state in detail the inspection requirements in paragraphs (a) to (e) of this section, and the repair station's inspection system including the continuity of inspection responsibility, samples of inspection forms, and the method of executing

them. The manual must refer whenever necessary to the manufacturer's inspection standards for the maintenance of the particular article. The repair station must give a copy of the manual to each of its supervisory and inspection personnel and make it available to its other personnel. The repair station is responsible for seeing that all supervisory and inspection personnel thoroughly understand the manual.

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